§19. Electron Transport Dynamics in LHD Core Plasmas

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The observed dynamics has different time and space scales. Plasma transport is dominated by turbulence, and thus the exhibited time and space scales of transport dynamics is considered to be resulted from the turbulence-transport interactions. To achieving a predictive capability of turbulence transport, therefore, understanding of the dynamics is crucial.

An spontaneous electron ITB (eITB) formation and a non-local electron temperature, T_e, rise have been observed in the Large Helical Device (LHD), which has negative magnetic shear and is free of net current. Neutral beams with a power of 2-4 MW are injected to initiate and sustain the plasma. The fundamental and the second harmonics of ECH is added with a power of 0.5-1 MW. Figure 1(a) shows a typical time evolution of T_e at the spontaneous eITB formation. A decrease in the density triggers an eITB formation in LHD. Electron ITB formation event propagates core to edge and then stopped near the low order rational surface (m/n = 2/1) as well as in tokamaks. The time scale of the ITB event propagation is 50 ms and is comparable to the energy confinement time of this discharge.

A typical T_e response to the edge cooling in LHD by a tracer encapsulated solid pellet (TESPEL) injection is shown in Fig. 1(b). Although the TESPEL affects only on the edge plasma, a sudden rise of T_e takes place in the central region ($\rho \leq 0.4$). Unlike the ITB formation, the plasma starts to go back to normal condition 30 ms after TESPEL injection as in tokamaks. Radial propagation of T_e rise is unclear because it takes place almost simultaneously in the core region ($\rho \leq 0.4$).

The spontaneous eITB formation and the non-local T_e rise takes place in the low-n_e and high-T_e (low collisionality) regime in LHD. The critical density for non-local T_e rise ($1.5 \times 10^{19}\mathrm{m}^{-3}$) is 2-3 times larger than that for eITB formation ($0.6 \times 10^{19}\mathrm{m}^{-3}$). The T_e changes discontinuously at the critical value. On the other hand, an increase in T_e induced by TESPEL injection gradually increases with decrease in the density. Although two phenomena are observed similar experimental conditions, physical mechanisms are considered to be quite different qualitatively. The time and space scales of two phenomena are quite different. The spontaneous eITB formation in LHD is characterized by narrow in radial region and slow in propagation time scale. On the other hand, the non-local T_e rise is characterized by wide in radial region and fast in propagation time scale.

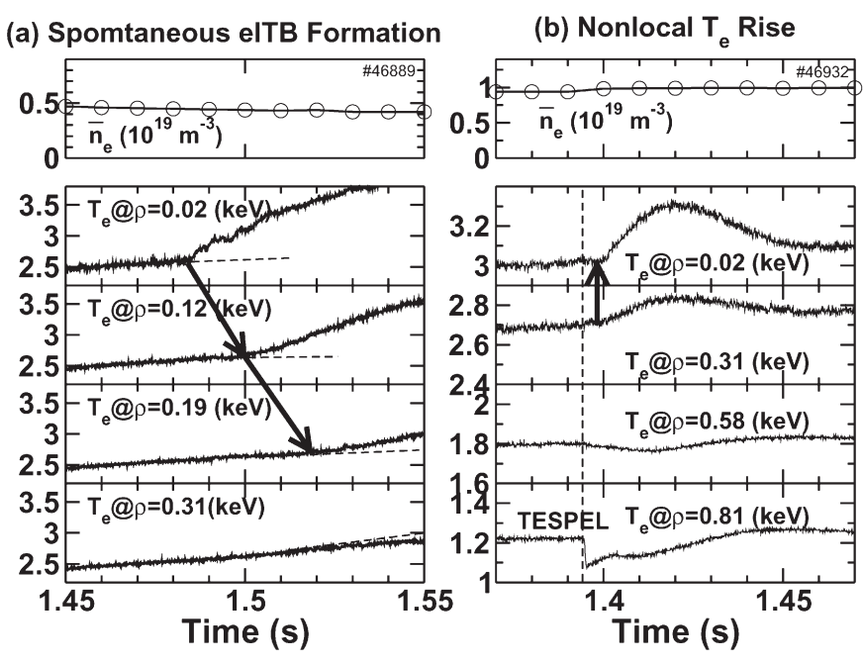

Fig. 1: Typical time evolutions of line-averaged density and electron temperature at different radii in LHD plasmas with (a) the spontaneous ITB formation and (b) the non-local T_e rise (a major radius at the magnetic axis of 3.5 m, an averaged minor radius of 0.56 m and a magnetic field at the axis of 2.829 T).